WEST AFRICAN COCOA RESEARCH INSTITUTE

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No. 47

GHANA
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WEST AFRICAN COCOA RESEARCH INSTITUTE

TAFO, GHANA

FORTY-SEVENTH QUARTERLY REPORT

JULY-SEPTEMBER, 1957

Any results recorded in this Progress Report should not be accepted as conclusive. The report contains interim information only. Final results are published in WACRI Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb
Deputy Director	C.G. Johnson
Scientific Assistant to Director	G.A. Jones
Secretary	H.L. Pugh (on leave 24th September)
Office Assistant/Librarian	Audrey Bryan
TAFO STATION	
Division of Entomology	P.F. Entwistle (on leave)
Division of Pathology	J.W. Blencowe (arrived 23rd July)
	A.L. Wharton
	A.A.F. Brunt (arrived 3rd September)
	A. Attafuah
Division of Botany	A.D. McKelvie (on leave 16th August prior to resignation)
	D.R. Glendinning
	R.G. Hurd
Division of Chemistry	T.A. Rohan
	E. Margaret Holden
	R.K. Cunningham
Division of Agronomy	R.J. Benstead
Laboratory Technician (electronics)	A.J.H. Arnold (arrived 6th August)
Plantations Manager	H.W.S. Allison
Maintenance Engineer	A. Maddison
Works Superintendent	E.K. Berko (appointed 17th August)
Guide-Demonstrator	F.E. Decker (on leave 4th July)
Station Manager	S.E. Ntim Kwafo (returned from leave 18th September)
IBADAN SUB-STATION	
Deputy Director (Nigeria)	T.W. Tinsley (arrived 24th July)
Entomologists	R.G. Donald
	C.K.H. Martini (arrived 1st September
Pathologists	J.M. Thresh (on leave)
	D. Kay

MANAGING COMMITTEE

The twenty-second meeting of the Managing Committee was held at Tafo on the 15th August. The Technical Sub-Committee met on the preceding day.

STAFF MATTERS

Mr. J. Lamb (Director), and Dr. T.A. Rohan flew to the United Kingdom on the 6th September to attend the London Cocoa Conference. Several other members of the staff who were on leave at that time, and some former members of the Institute's staff, also attended the conference.

Mr. A.D. McKelvie read a note on "Rooting Cocoa Cuttings under Polythene", and presented a paper by Mr. D.R. Glendinning on "The Performance of the Introductions and Hybrids in W.A.C.R.I. Trials". A joint contribution on "The Pollination of Cocoa Flowers" was submitted by Dr. A.F. Posnette and Mrs. H.M. Entwistle, while the session on disease and pest control included "A Capsid Control Experiment in the Western Region of Nigeria" by Mr. R.G. Donald, "Pest Control Research at W.A.C.R.I." by Mr. D.J. Taylor, and "The History and Control of Cocoa Swollen Shoot Disease in Nigeria" by Mr. R.M. Lister and Mr. J.M. Thresh. A paper entitled "Observations on the Fermentation of West African Amelonado Cocoa" was read by Dr. Rohan, who also gave a paper on "Polyphenols and Quality in West African Amelonado" at a restricted scientific session on the chemistry of fermentation.

Dr. T.W. Tinsley arrived at Ibadan on the 24th July to take up his appointment as Deputy Director (Nigeria). Dr. Tinsley spent a few days at Tafo in August, and attended the meeting of the Managing Committee. Dr. C.K.H. Martini joined the staff of the Sub-Station as Entomologist on the 1st September.

At Tafo, Dr. J.W. Blencowe assumed duties as the head of the Pathology Division on the 23rd July, and another Pathologist, Mr. A.A.F. Brunt, arrived on the 3rd September. Mr. A.J.H. Arnold arrived on the 6th August to take charge of the maintenance of laboratory equipment. Mr. E.K. Berko was promoted to Assistant Specialist (Works Superintendent) on the 17th August.

Mr. A.D. McKelvie has resigned from the Institute to take up a post at the Plant Breeding Institute, Cambridge.

VISITORS

In August the Institute was honoured by a visit from Chief the Honourable G. Akin Deko, Minister of Agriculture and Natural Resources, Western Region, Nigeria, accompanied by

Mrs. Deko, Mr. Gunton, and Mr. Rotilu. Following the meeting of the F.A.O. Cocoa Study Group at Ibadan in September, 22 delegates paid a visit to the Tafo Station. Mr. Boerma, Director of the Economics Division of the U.N. Food and Agriculture Organisation, visited the Institute with Mr. Abercrombie on the 13th September.

Other visitors have included Lt. Gen. Sir C.G. Packard; Sir Sidney Ridley of the West African Committee; members of the German Goodwill Mission to Ghana; a party of officers from the Imperial Defence College; Mr. K.F. Markley of the U.S. - Brazilian Joint Technical Agricultural Organisation; Mr. Hemerich of the American Embassy in Ghana; and Mr. Devondel of Unilever Limited. A tour of the Station was arranged for the students attending the World Student Seminar at the University College.

Dr. V. Eastop of the British Museum has spent some months at Tafo studying aphids and white flies.

Visitors to the Sub-Station have included Mr. O. Bademosi of the Federal Ministry of Research and Information, with Mr. G.A. Nwanze; Mr. John Cadbury of Bournville and Mr. D.H. Joss of the Cocoa, Chocolate and Confectionery Alliance, London; and Dr. Albert Viton of the F.A.O.

MANAGEMENT AND MAINTENANCE

Work has started on the construction of extensions to the main laboratory block, and to the workshops. Good progress has been made on the new bungalows, and a site has been prepared for quarters to accommodate the Police Force which is to be established at the Institute. In preparation for the A.C. electricity supply all buildings have been rewired.

A new vegetable garden has been prepared and planted.

CROP DELIVERY

Harvesting of the major crop started in August, with a total of 49,589 pods collected up to the end of September. In the Uniformity Trial Area the number of diseased pods, as indicated by discards at fermentation, was 8.5 per cent, compared with 3.8 per cent for the same period last season, but the incidence of black-pod disease appeared to be decreasing towards the end of the quarter. A good crop is in evidence on all the young cacao, particularly on those areas where shade has been completely removed.

In the experimental areas pod miner (Marmara sp.) has been widespread. The effects are superficial, but pods are often so discoloured that it is difficult to assess ripeness.

SWOLLEN SHOOT DISEASE

Losses during the quarter from the Uniformity Trial Areas due to swollen shoot disease and other causes are given below.

Month	Trees destroyed		Total	Infected seedlings removed
	Swollen Shoot	Undiagnosed		
July	31	7	39	24
August	59	4	63	93
September	21	5	26	52
Total	111	16	127	169

Swollen shoot control at the Institute has been reorganised and placed under the technical supervision of the Pathology Division. All trees are now inspected monthly and diseased trees removed. Where experiments permit contact trees are also removed. As a result of the reorganisation a large number of trees were cut out during the quarter but it is hoped that the number of trees found infected will decrease substantially in the months ahead.

UPPER AMAZON SEED

A total of 1908 pods of Upper-Amazon F3 approved types were sent to Eastern Region, Nigeria, during the quarter.

METEOROLOGY

Month	1957		19-year mean	
	Rainfall (in.)	Wet Days	Rainfall (in.)	Wet Days
July	16.04	23	5.23	13.6
August	1.97	18	2.52	12.8
September	4.73	18	6.17	14.6
Total	22.74	59	13.92	41.0

TAFO STATION

PATHOLOGY DIVISION

VIRUS RESEARCH

Resistance and tolerance

The testing of cacao plants for resistance or tolerance to virus infection is being continued on an increased scale. The third replicate of tests on clonal cuttings from selected F_1 T/17 (Iquitos) seedling trees is in progress.

Classification and comparison of virus isolates

Studies on the relative virulence of cacao viruses in seedlings (cf. Quarterly Report No. 46) have revealed that although the woody parts of the plant above soil level may show no symptoms, conspicuous swellings are almost invariably found on the lower part of the tap root. Lesser swellings have often been found on the minor roots. Similar observations have also been made in the field on some trees infected with virus of the mild New Juaben type. The root-swellings observed were on seedlings that had been artificially infected at the bean stage more than eight months previously, and the examples found in field material were trees that had probably been infected for a considerable time.

Experiments on the relative virulence of isolates of the Kpeve type are continuing.

Work done on cacao viruses up to the present time suggests that they can be divided into two main groups. The name Cacao Swollen-shoot Virus should be reserved for the group which at present embodies the greater number of isolates, whose symptoms, generally speaking, include swellings of the stem or root. The virus from Kpeve, described as "mottle leaf" by Posnette (1947), which does not produce swellings in cacao stems or roots, is typical of a number of isolates which may be grouped together under the name Cacao Mottle-leaf Virus.

Host plants of cacao viruses

Successive tests on infected plants of a number of species have shown that virus is not continuously available to mealybugs that are, from time to time, put to feed upon them. For instance, back-tests from plants of *Cola chlamydantha* and *Hildegardia barteri* infected with an isolate from Offa Igbo were positive during a period of 30 months. Subsequent back-tests were negative until the plants were coppiced, when successful virus transmissions were made to cacao by feeding

mealybugs upon the new growth arising from the base of the coppiced plants. By contrast, plants of H. barteri infected with the Kpeve isolate continued to yield positive back-tests until the plants were coppiced, but subsequent back-tests have been negative.

Transmission Studies

The virus isolates Nsaba, Bisa, Bosomuoso (2) and Ankra-Nkwanta have been successfully transmitted by the mealybug Planococcus citri. Plants grown from the seed of virus-infected Adansonia digitata were found to be virus free.

STUDIES ON BLACK-POD DISEASE

There have been much greater losses from black-pod infection (Phytophthora palmivora Bull.) on cacao in 1957 than in recent years, because of the unusually long rainy season. Numbers of diseased pods reached a peak in June and July, and did not fall to very low levels in August. In September, numbers of 'black pods' started to increase again, and many more infections are to be expected in October.

Effect of age and size of pod on susceptibility

The title of the field experiment on which these studies are based is retained for convenience of reference to previous quarterly reports, but the scope of the investigations (cf. 42nd Quarterly Report) has increased considerably to provide basic information on seasonal outbreaks of black-pod disease. Results for the 1956-57 season have been summarised and will be reported in detail in the next Annual Report. Some of the main points are:

1. Despite the heavy early rains in April and May 1956, the first outbreaks of black-pod were not observed until June. This was probably because the total surface area of pods exposed to infection was at a minimum until, in June, a large proportion of the pods started to swell and increased rapidly in surface area.

2. The first disease outbreak was largely limited to infections of cherelles, and occurred at the time when physiological wilt was most prevalent. The evidence suggests that most of these diseased cherelles would in any case have been lost from cherelle wilt, and hence this did not represent an immediate loss of crop. However, their importance as a source of infection later in the season merits greater attention, and will be studied on these trees next year.

3. There is no correlation between the number of 'black

pods' on the trees during the year and the seasonal distribution of total fruits.

4. If all recorded fruits are divided into three age classes - viz. cherelles, large immature pods and ripe-pods - the number of diseased cherelles is closely related to the total number of cherelles in June and July, and a similar relationship is found for diseased and total ripe pods over the period September to November. The number of large immature infected pods, however, did not reach a maximum when this class of pod was most numerous during the "short dry season" month of August.

The outbreaks of pod disease in this year (1956) can, therefore, be related to the total number of fruits of varying ages present on the trees at the times of the year when climatic conditions were suitable for development and spread of the pathogen.

Records have been continued in 1957 of the sites of primary Phytophthora infections on individual cacao pods. This year all infections at the stalk-end of the pods were designated as lateral infections unless the peduncle of the pod was diseased, in which case they were recorded as proximal infections. These 'site of infection' records for the months May to September are given in the following table:

Month	Site of infection		
	Proximal	Lateral	Distal
May	-	3	9
June	5	42	67
July	16	91	77
August	19	43	7
September	30	48	9
Totals	70	227	169

N.B. Figures are for total infections, including multiple infections on single pods.

The table shows that unlike distal and lateral infections, which declined in number after reaching a peak in July, proximal infections were increasing steadily up to the end of September. If these proximal infections arose from diseased cushions it would support the impression gained in

previous years that seasonal epiphytotics of black-pod disease do not start from infected cushions, because infections from the latter are not numerous until after the appearance of large numbers of pods with lateral and distal infections which must have arisen from spores. All the cushions have been labelled and later in the year they will be examined for the presence of the pathogen.

Strains of Phytophthora palmivora Bull. occurring in Ghana and Nigeria

Fifty-three isolates of P. palmivora have been collected from widely scattered districts covering all the cacao areas in Ghana. All are being sub-cultured from single spores preparatory to comparing them in laboratory tests. A number of isolates are to be brought from Nigeria to Tafo for similar laboratory tests in artificial culture.

Resistance and tolerance

During the quarter large numbers of "black pods" were recorded on all selections in the 1st Clonal Trial area. An analysis of the infections up to the end of July, in relation to the total crop harvested, is being made by the plant breeder. If the disease had been allowed to build up as originally planned (cf. Quarterly Report No. 46) very few pods would have survived. Observations have therefore been divided into two parts, and all diseased pods were removed from the area in September. Recording is now continuing on the main crop.

ENTOMOLOGY DIVISION

CAPSID STUDIES

Joint WACRI and Department of Agriculture Capsid Control Trials

Experiments using aldrin, gamma-BHC and malathion at 4 oz. in 5 gallons water/acre (2 applications at a 4 week interval) have been made on small plots of 3-4 acres. A greater accuracy than hitherto has been achieved in the experimental layout (see Quarterly Report No. 46). The indications are that after two and a half months from the last application there was little new damage on all aldrin and gamma-BHC plots (the latter slightly favoured): but that the malathion plots showed more damage than should be tolerable after spraying.

On the three large-scale plots (88, 95 and 117 acres) 16 half-acre sample units in each plot were assessed for tree density, new damage and canopy regeneration. The results indicate that eight weeks after the second application (4 oz. in 5 gallons/acre) the amount of damage on the endrin and aldrin plots was tolerable, with the difference in favour of endrin, while the dieldrin plot showed much more damage.

Final assessment of these experiments awaits the data for canopy regeneration. New damage assessment alone may not be a reliable guide for the effects of a spray, as in some plots the level of damage might have been low even without spraying. Therefore untreated controls should show, on the average, more new damage than treated plots, or if not, at least less canopy regeneration, before a low level of new damage or an increase of canopy regeneration in treated plots (compared to that on controls) can be taken as a result of spraying.

Taint tests

Areas at Bunso have been heavily sprayed twice, at a four weekly interval, with aldrin (6 oz./acre), endrin (6 oz.), malathion (8 oz.) and dieldrin (6 and 16 oz.), all in 5 gallons of water/acre.

Samples of pods are being collected one day after the first and one, four and eight weeks after the second spraying; pods from unsprayed plots being collected as controls. Two replicates from each treatment are fermented in 150 lb. heaps, and the dried beans sent by air to the British Food Manufacturing Industries Research Association for tasting trials.

Pod-husk miner

The small lepidopteran (Marmara sp.) which causes the well-known "scribbling" on pods has become extremely prevalent at WACRI and elsewhere. This damage, though without effect either on the quality or quantity of beans, sometimes makes it difficult to tell if pods are ripe: and in any case it is unsightly, and possibly disturbing to farmers.

A recent survey of sprayed and unsprayed cacao indicates an association between spraying and increase in the incidence of miner. Experiments are now planned to show if this is due to increased dosage of spray, or increased frequency, or if a high incidence of miner follows the use of a particular chemical. The increase in miner population may be due to a disturbance of the balance of the predators and parasites which normally keep the miner in check, and work on the natural history

of the pest will also be desirable.

MEALYBUG STUDIES

Joint WACRI and Department of Agriculture trials on mealybug control

1. Oyoko. Eleven months have now elapsed since the first application of dieldrin and during the last eight months of this period the numbers of adult mealybugs found in counts made on whole mature trees have fluctuated between 1 and 10 per cent of the initial level. During this time the data show that the numbers of mealybug colonies have fluctuated between 10 and 20 per cent of the initial counts and that the majority of colonies consist of nymphs only. Counts made to hand height show a similar pattern though naturally at a lower numerical level.

However, data from the control plot show that this decline is at least partly due to seasonal factors (see Quarterly Progress Report No. 46), though this does not by any means account for the constant extremely low level of populations maintained in the treated area.

2. Isolated outbreaks. In the experiments on isolated outbreaks ten months have elapsed since the first application of dieldrin. During the last eight months counts to hand height have shown that numbers of adult mealybugs have fluctuated between 5 and 10 per cent of pre-treatment levels. Application of malathion to half of the total plots had no observable effect on populations of adult mealybugs.

3. Square Mile. Despite the fact that during the past five months numbers of adult mealybugs in the control area fell considerably, probably due to climatic factors, numbers in the dieldrin treated area remained consistently lower, fluctuating between 8 and 16 per cent of pre-treatment figures. In terms of adult mealybugs per infested tree the present level in the treated area is approximately 10 compared with over 100 in the pre-treatment period. Only 29 per cent of trees are now infested with Pseudococcus njalensis as against 61 per cent prior to spraying. Application of malathion to half of the treated sub-plots had no observable effect on mealybug populations.

Formicide trials

The trials comparing various insecticides for the control of ants (see Quarterly Progress Report No. 45) have now ended, most of the ant populations having returned to a level comparable with that before spraying. The final results of these trials await further assessment of the data.

BOTANY DIVISION

PLANT BREEDING AND SELECTION

After the heavy crops in May harvests from the experimental plots have been small during the quarter, but are starting to build up again. The cacao in the Introductions Area has been heavily attacked by black-pod disease, and fungicidal control measures have been applied.

Many of the Amazon cacao types are highly tolerant to virus infection and show only mild or transient symptoms even when infected by the most virulent strains. To reduce the risk of spreading cacao viruses when exporting cuttings from these types a new system of quarantine is being introduced. The clones are budded onto susceptible Amelonado stocks, which are then allowed to produce shoots. Infected material is revealed by the appearance of disease symptoms in the new shoots. A small reserve of material shown in this way to be free from virus will be maintained at Tafo, but to cater for the large quantities required by Nigeria unquarantined budwood is being supplied which will be tested by the receiving authorities.

Experiments involving the fermentation of single hand-pollinated pods have been started. The pods are derived by either self- or cross-pollination from parents giving cocoa with different percentages of fat, and it is hoped that this work will show whether the nature of the cocoa is influenced by the pollinator parent. Using small-scale heap fermentation an assessment is being made of the variation between selections of the ratio of conversion from wet cocoa to dry.

Data on bean size, taken from ordinary commercial cocoa, have been supplied by the Produce Inspection service of the Department of Agriculture, Western Region, Nigeria, for analysis. Samples, each of 100 beans, were selected from seven areas, one sample being taken from each area in December, 1956, early and late January, 1957 and February, 1957. For all 28 samples the number of beans in different weight classes, ranging from under 0.5 gm. to over 1.5 gm. with 0.1 gm. intervals, was recorded and also the length and breadth of each bean. In the December samples bean thickness was noted instead of breadth.

In general, histograms of the bean weight frequency distribution resemble a normal distribution, but are negatively skewed. Some samples, however, gave a distinct two-peaked histogram, suggesting a mixture of small and large beans.

In all the samples, but particularly in those taken in February, a substantial proportion of the beans weighed less than 1 gm. Altogether 35 per cent of the beans, equivalent to 26 per cent of the total weight, fell into this category. The corresponding proportion in the February samples amounted to 40 per cent of the beans, reaching a maximum of 66 per cent in one sample. In every case the spread of bean weights was fairly broad, with beans below 0.6 gm. and above 1.4 gm. in all the samples but one.

The relationship between length and thickness has been investigated for only one sample. In this case the mean length was 22 mm., and the mean thickness 3.4 mm., but there was no correlation between length and thickness.

In recent years all pods of the approved types have been distributed as seed. As a result no data are available for these types regarding the weights of cocoa per pod, and to calculate yields it has been necessary to use an estimated figure. It has been noted, however, that these weights have fluctuated considerably in other types in the Introductions Area. In the early years the relative fluctuations of the individual types seeme to be quite at random, but over the period 1954 to 1957 the variations have followed a uniform pattern. The varieties in this area can be divided into five classes: a) West African Amelonado; b) pure-bred Amazon cacao, approved types; c) pure-bred Amazon cacao, other than approved types; d) Amazons out-crossed to other types; and e) types which are neither West African nor Amazon, including Criollos and Trinitarios. Mean weights of cocoa per pod for each of these classes, from 1951 to 1957, are given in the following table, together with weight indices based on the 1951-52 figures.

Class	Mean weight of cocoa per pod, gm.					
	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57
a) West African Amelonado	98.4 (100)	115.6 (117)	N.D.	107.5 (109)	116.1 (118)	103.0 (105)
b) Pure-bred Amazon approved types	106.1 (100)	N.D.	115.5 (109)	N.D.	N.D.	N.D.
c) Pure-bred Amazon unapproved types	88.5 (100)	N.D.	N.D.	107.1 (121)	112.2 (127)	92.5 (105)
d) Amazons out-crossed	101.7 (100)	N.D.	111.1 (109)	119.1 (117)	132.9 (131)	112.8 (111)
e) Other types	110.6 (100)	112.1 (102)	N.D.	128.0 (116)	136.0 (123)	118.3 (107)

N.D. - data insufficient or non-existent.

The West African group had a relatively much heavier pod in its early years, but otherwise the results for the different classes have followed parallel courses, and it seems justifiable to interpolate mean pod-weights for the approved Amazon types, where the data are lacking. The actual estimates used are as follows:

1954-5	123 gm.	(118)
1955-6	134.5 gm.	(127)
1956-7	114.5 gm.	(108)

The index numbers again refer to 1951-2 as base year.

Following the indication from the 1st Clonal Trial that early girth measurements are related to later yield in clones (cf. Quarterly Report No. 43), similar relationships have been sought in the varieties planted in the progeny trials.

The 8th Progeny Trial was planted in 1952. Height measurements were taken in June and September, 1952 and March 1953, while diameters were measured in December 1952, March 1953, November 1953 and in November or December in each subsequent year. If varieties are ranked on the basis of stem diameter, the order is found to have remained substantially unchanged since December, 1952, and those varieties which are now most vigorous in vegetative growth were outstanding even at that time.

The relationship of these various measurements to yield has been studied using scatter-diagrams of plot means. Both present diameters and diameters in 1953 are related to the total yield of wet cocoa to date, but in neither case is the correlation close for a particular variety, and there is considerable variation between varieties. The pure-bred Upper-Amazon types, for example, are cropping more heavily in relation to their girth than are the other types. Both present diameter and total yield to date are related to the height increase between June and September, 1952, but because of varietal differences it does not appear possible to forecast the future performances of selections from early height increments with any useful degree of accuracy.

In the 9th Progeny Trial, planted in 1954, relationships are apparent between present stem diameter and present cropping, between early increments in stem diameter and present diameter, and between early increments and present cropping. Again, however, certain types, particularly one pure-bred Upper-Amazon type, are cropping at a lower stem-diameter than are most of the

other types. It may be worth noting that differences in the fertility of plots growing the same variety can be recognised from the girth measurements taken after the trees had been only five months in the field.

Comparisons of clones and progenies have been attempted using the 14 clones in the 1st Clonal Trial, progenies of which are growing in the 2nd Progeny Trial. The 2nd Progeny Trial was planted in 1942, and the 1st Clonal Trial in 1947; the progenies were obtained by self-pollination from the original trees from which the clones were later propagated. Rather surprisingly, there seems to be no relationship whatever between these clones and their progenies in yielding capacity, the calculated correlation coefficient for number of pods up to 1955-6 for the Progeny Trial and number of pods up to 1956-7 for the Clonal Trial being only .0014. However, an indication was found of a correlation between the percentage of pods borne on the branches of the trees in the progeny trial and the yield in the clonal trial ($r = .434$, probability about 0.1).

A similar investigation has been initiated on the 13 selections in common between the 2nd Clonal Trial and the 2nd Progeny Trial. Plotting the data in a scatter-diagram, there is an indication of some relationship between performances as a clone and as a progeny, though it is far from close. Again, however, there appears to be a relationship between performance as a clone and the percentage of pods on the branches of the progeny.

VEGETATIVE PROPAGATION

Fertilizer on cuttings

The experiment to investigate the effect of fertilizers on the rooting and subsequent growth of cuttings (see Quarterly Report No. 44) is being repeated, with some modifications. The present experiment has been laid down in a 2^2 factorial design, with fertilizer treatments based on a) an initial PKMg application, and b) a dressing of N, applied as urea solution after the cuttings have hardened. For each combination there are six replicates, composed of 20 cuttings. Cuttings have been taken from an easily rooted selection, S27, for half of the replicates, and from a poor rooting selection, A72, for the remainder. Each set of six replicates has been subdivided into three pairs, with cuttings from both selections in every pair. One pair has been placed under 10 per cent sunlight, another under 25 per cent sunlight, while the third

was under 10 per cent sunlight for the first fortnight, and was then transferred to 25 per cent sunlight. This latter treatment was indicated by the results of the earlier experiment.

Stimulation of new chupon growth

An experiment is being carried out to compare the efficiencies of different methods of stimulating new chupon growth. The treatments given include the removal of the terminal bud and semi-ring-barking with and without the application of lanolin containing 20 p.p.m. adenine sulphate and 5 per cent sucrose - a mixture which has been shown to induce bud growth in other plants. Nine month old Amazon seedlings are being used. A mixture of N,P,K, and Mg fertilizers have been applied, and the seedlings are receiving monthly applications of urea to stimulate vegetative growth and rapid development of new chupons.

It would also be useful to be able to induce chupon growth on clonal cacao which has only fan type branches. A study is being made of the result of budding chupon budwood onto clonal material and vice versa.

PHYSIOLOGY OF NUTRITION

Water culture

A simple experiment to investigate the effect of shade on the growth of Amelonado seedlings has been started. Six seedlings have been set up in water culture inside an insectary, where the light intensity is approximately 40 per cent of sunlight, while another six have been set up outside. The seedlings are provided with the same nutrient solution, of a composition found satisfactory in earlier experiments, and the pots are lagged so as to maintain the same solution temperature in both treatments. The seedlingswere originally grown in baskets inside an insectary, and were transplanted to water culture when three months old. Despite precautions to prevent shock the seedlings transferred to full sunlight have been retarded, but they now appear to be recovering. The use of water-culture in an experiment of this sort eliminates the complicating factor of insolation of the soil and roots, so that the effects of shade on the aerial parts of the plant can be determined.

Uptake of radio-active phosphorus

In the experiment using radio-active phosphorus preliminary calculations of uptake have been based on an approximate self-absorption correction factor. A more accurate assessment of this factor has now been made by comparing the

activity of a solid sample with that of an aqueous solution prepared from it after dry ashing.

CHEMISTRY DIVISION

SOIL FERTILITY

Effect of major nutrients on cocoa

All fertilizer field experiments at WACRI, in the Eastern Region, and in Ashanti, were given their second nitrogen application for 1957 at the end of September and the beginning of October. It was added either in the form of urea or sulphate of ammonia. In September routine spraying for the control of black-pod disease was introduced in the Shade and Manurial Trial at WACRI.

Pot experiments

The experiment designed to test the effects of K and Mg ended in July. It was conducted along the same lines as the "types of N" experiment mentioned in Quarterly Report No. 45. Apart from the no-treatment control all pots received a basal NP treatment and the effects of K and Mg were assessed by comparison with the pots receiving only N and P. The types of fertilizers with rates and frequencies of application are shown below:-

Type	Amount of element	Frequency of application	Reference
Sulphate of Potash (48% K_2O)	0.25 gms K/pot	once	K_1
	0.50 gms K/pot	once	K_2
Magnesium Sulphate $MgSO_4 7H_2O$ (16% MgO)	0.10 gms Mg/pot	once	Mg_1
	0.20 gms Mg/pot	once	Mg_2
Urea	0.5 gms N/pot	once per month	N
Ammonium phosphate	0.2 gms P/pot	once per month	P

The experiment covered a period of six months, starting in January, 1957. In the dry season (January, February, March), and especially under harmattan conditions, practically no growth occurred, and the cacao did not begin to flush until wetter and more humid conditions started in April. All plants were sprayed weekly with dieldrin.

The effects of the fertilizer treatments were measured by the increase in height of the seedlings from the time of the first treatment until the termination of the

experiment. Six replicates were used for each treatment, and the following table shows the mean height increment.

Treatment (Per Pot)	Mean height increment of seedlings over 6 months period
NIL	29.5 cms.
NP	33.7 cms.
K_1NP	38.7 cms.
K_2NP	39.1 cms.
Mg_1NP	62.3 cms.
Mg_2NP	41.8 cms.
K_1Mg_1 NP	50.1 cms.
K_2Mg_1 NP	42.2 cms.
K_1Mg_2NP	32.3 cms.
K_2Mg_2NP	49.8 cms.

Standard Error of difference of mean height increment = 7.0
Degrees of freedom for error = 45

COCOA PREPARATION AND QUALITY

The products of a number of 20 lb. fermentations subjected to varying treatments have been assessed for quality by a panel of the C.S.A.C. The results confirm that these small heaps can be fermented successfully but that prevailing atmospheric conditions influence the course of fermentation, which can be ruined by heavy rain or low night temperatures. The most successful treatment was four days fermentation without mixing, which supports the theory that reduction in batch size is accompanied by proportionally greater air penetration and more rapid and uniform death of the beans.

While such small quantities can be fermented successfully, the procedure is not to be recommended for general use by the farmer. Where it is absolutely necessary, however, the cocoa should be well insulated with plantain leaves, preferably with the base of the heap raised from the ground on sticks, and fermentation should be allowed to continue for four days, with one mixing after approximately 30 hours.

Recent investigations have shown that the optimum weight for heap fermentation is of the order of 500 lb. wet cocoa, and that this quantity can be properly fermented in four days with one mixing.

A method has been devised for the rapid fermentation, in bulk, of Amelonado cocoa and it is hoped that large scale trials can be made in the new fermentation house before the end of the present crop.

Studies on cacao enzymes

The pulp of cacao beans has been found to contain a germination inhibitor which, under normal conditions of fermentation, will effectively prevent germination taking place. The inhibitor can be removed by washing the beans, which then germinate much more rapidly than unwashed beans, particularly when kept at a temperature of 35°C. The inhibitor appears to be broken down fairly rapidly by micro-organisms, as under normal conditions beans germinate in about a week. Archibald (Quarterly Report No. 33), however, found that under sterile conditions germination may be delayed by as much as a fortnight.

Aqueous extracts of pulp, whether at the normal acid pH or after neutralization, inhibit the germination of mustard seeds, and this has been used as the basis of a test for comparing the concentration of inhibitor in pods at different degrees of maturity. It has been found that the pulp of fully-grown unripe pods has almost ten times as much inhibitor as the pulp of slightly over-ripe pods. Acetone extracts of pulp have been chromatographed in an attempt to separate the inhibitor, but so far no useful results have been obtained. A substance, which is an inhibitor of mustard seed germination and which has been tentatively identified as p-coumarylquinic acid, has, however, been separated from cacao leaf extracts by chromatography. Little is known of the effect of germination inhibitors on enzymes, but it is reasonable to suppose that they will inhibit enzymic reactions concerned with germination changes. If the inhibitor in cacao pulp has this effect the theory that some of the preliminary stages of germination take place during the early stages of fermentation may no longer be tenable.

I B A D A N S U B - S T A T I O N

PATHOLOGY SECTION

VIRUS RESEARCH

The effect of varying the number of mealybugs used in transmission on the speed of development and the type of symptoms produced

The results of these experiments have shown that the period between infestation and appearance of symptoms is affected by the number of mealybugs used in the transmissions. Little variation in latent periods was found within any one treatment, i.e. number of insects. The rate of infection and type of symptom seemed to depend more on infestation rate than on the virus availability in the source.

Measurements of leaf area and stem height were made on the infected seedlings three to four months after planting. Seedlings infested with the highest number of insects had the smallest leaf area and were greatly stunted.

Virus availability in mature cacao

Four fully-grown pod-bearing trees were selected and graft-inoculated with Olanla virus isolate. After 75 days, two produced typical symptoms while two remained latent. Samples were collected and back-tested weekly from the two groups of trees, until one of the latent trees was found with symptoms. In 341 tests on samples from the trees with obvious symptoms, virus was transmitted in 85 cases, compared with 33 infections in 353 tests on samples from the latent trees.

These results confirm those of previous experiments in Nigeria suggesting that virus is more readily available to mealybugs in trees showing symptoms.

I.N.A. coppicing experiment

Records from the coppicing trial at the Ibadan Native Administration farm reveal that trees coppiced during the dry season (December) are doing better than those coppiced at various other seasons of the year.

STUDIES ON "DIE-BACK" OF CACAO

Existing areas

An experiment has been started on three plots of farmer's cacao at Araromi (Western Region), to compare the rate of increase of existing areas of die-back in trees which have been treated with insecticides to control capsids and in untreated control trees.

One of the three plots had received 4 oz. gamma-BHC (as Gammalin 20) per acre, applied with a mistblower, at monthly intervals from August, 1956 to February, 1957. In the present experiment this treatment has been followed by the application, with a knapsack sprayer, of 4 oz. gamma-BHC per acre at 28-day intervals during August, September and October, 1957. Over the same period the second plot has been treated with 40% aldrin at 4 oz. per acre, again at 28-day intervals. The third plot has been left untreated, and will serve as a control. Disease records are being taken on 100 trees in each of the three plots.

Fungi isolated from capsids, lesions and wounds

Cultures have been made of fungi occurring in capsid lesions and in recent mechanical wounds on two cacao trees. The trees were newly regenerated and consisted largely of young growth. Isolates of Botryodiplodia theobromae Pat. and of the genus Fusarium were found in the mechanical wounds but more isolations are required from wounds and injuries on cacao before an accurate comparison can be made with fungi from capsid lesions. Cultures prepared from capsids (Sahlbergella singularis Hage) collected in the field showed that only a small percentage were carrying Fusarium decemcellulare spores.

The effect of the presence of Calonectria rigidiuscula (Berk. and Br.) SACC. in coppiced stumps, on the regeneration of Theobroma cacao (L.)

The majority of the 90 trees coppiced in June, 1957 (see Quarterly Report No. 46) have now produced chupon growth. Details, expressed as "percentage of coppiced stumps producing chupons", are given in the following table:

Percentage of coppiced stumps producing chupons

Treatment	Trees with fan canopy	Trees with only main trunk alive	Trees alive at base only	Average
Calonectria in the sapwood of the trees	70	50	50	57
Calonectria in the heartwood of the trees	100	60	70	77
No Calonectria	60	70	70	67

Cushion development appears to be unaffected in regions adjacent to the introduced Calonectria.

It is too early to draw conclusions from this experiment but the results indicate that the presence of the fungus Calonectria in the coppiced stumps does not prevent the initial regeneration of the cacao tree.

ENTOMOLOGY SECTION

Minor pests

The collecting and rearing of minor pests of cacao has continued, particular attention being paid to Homoptera. Two species of Ricanidae have been reared from nymphs feeding on cacao flush leaves. The cacao psyllid (Tyora tessmanni Aulm.) has been recorded both on cacao and Cola nitida. Leafless cacao buds collected at Moor Plantation were not found to be infested with red-mites. This is in contrast to those found in June on trees suffering from "Leafless Twig Disease" in the Cameroons. The prolific development of the lateral buds, which is a characteristic feature of the disease in the Cameroons, does not occur at Ibadan, and true "Leafless Twig Disease" may be absent from the area.